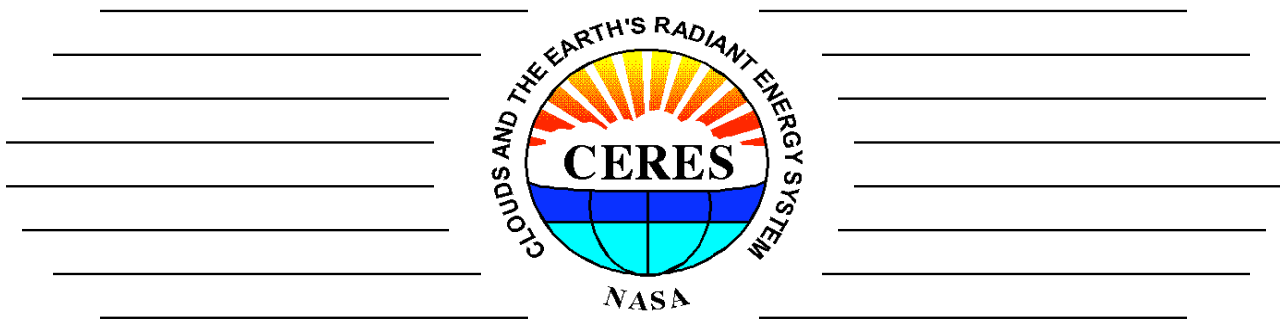
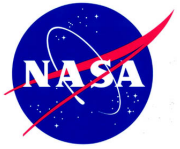
Spectral Response Functions for CERES Sensors



Susan Thomas, Kory Priestley
Mohan Shankar, Suzanne Maddock

CERES Instrument Group

CERES Science Team Meeting
Newport News, Virginia
April 29, 2009



NASA Langley Research Center
Atmospheric SCIENCES

Radiance Determination

The measured radiance for a scene:

$$\tilde{L} = \int_0^\infty L(\lambda) S(\lambda) d\lambda$$

L(λ) – unfiltered radiance from the target scene

S(λ) – spectral response of the sensor

The optical elements of the sensor include

- Primary and secondary silver mirrors
- Black paint on the active bolometer
- Filters in shortwave and window sensors

CERES Spectral Response

$$S_\lambda^j = \rho_\lambda^2 \tau_\lambda \alpha_\lambda \Big|$$ j= tot, sw, wn

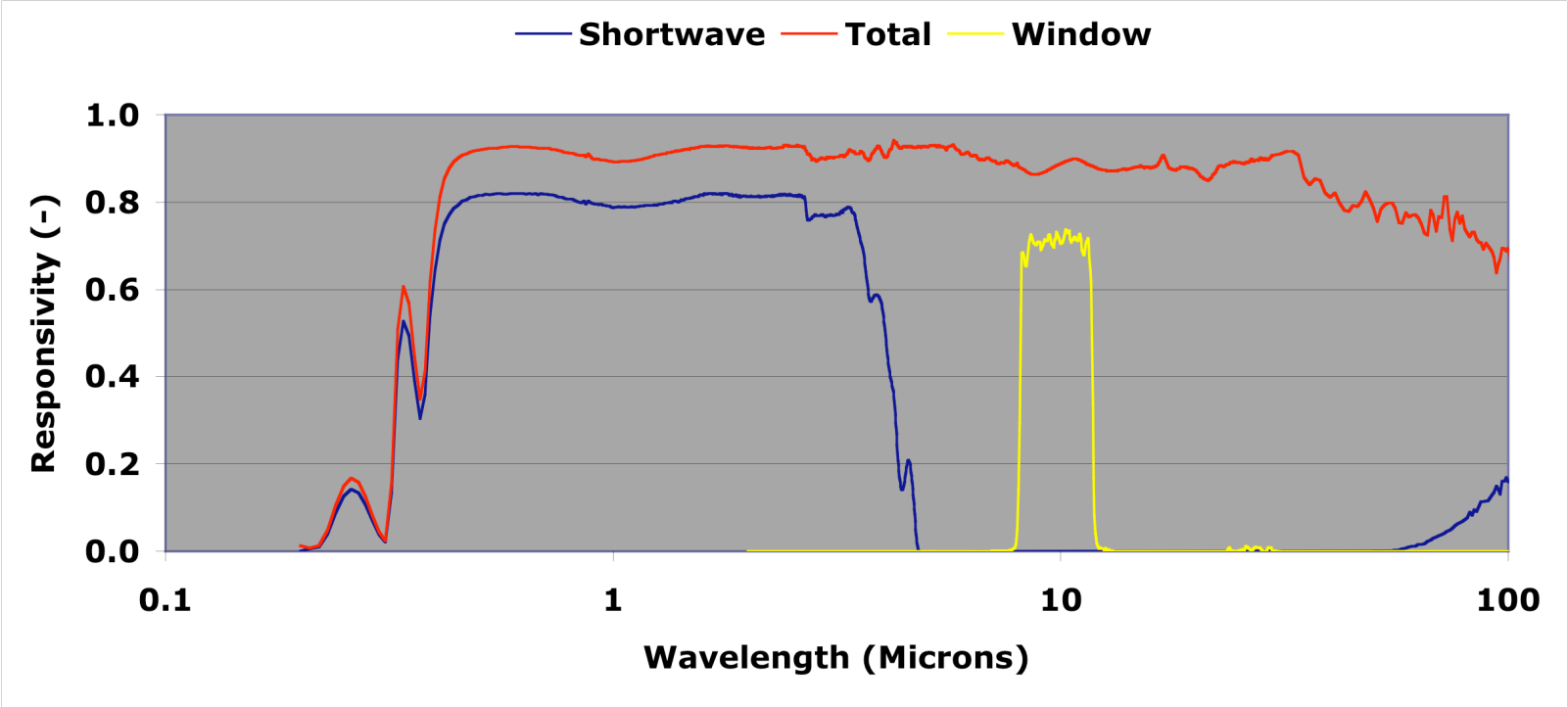
ρ_λ is the spectral reflectance of the silvered mirrors

τ_λ is the spectral transmittance of any optical filters

α_λ is the spectral absorptance of the detector

CERES Spectral Response Function

Proto Flight Model



0.2 – 2.5 μm

2.5 – >100 μm

SWRS

Fourier Transform Spectrometer

CERES Spectral Characterization

- Measurements of the optical components in the 0.2 to 2.5 μm region are achieved using Cary 5 grating spectrometer with the witness samples.
- BIO-RAD Fourier Transform Spectrometer is used to measure the response in the region beyond 2.5 μm.

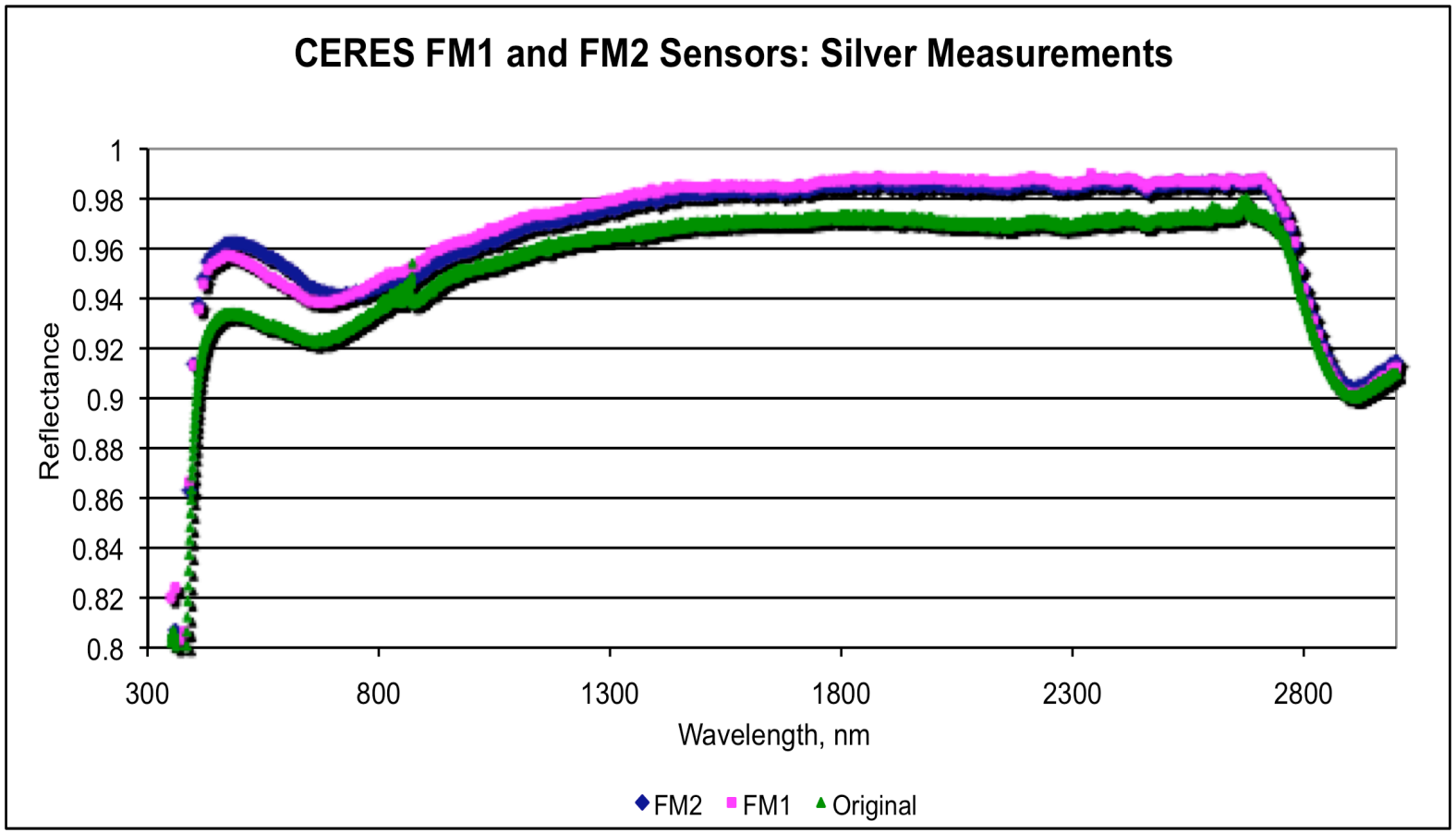
Shortwave Spectral Characterization

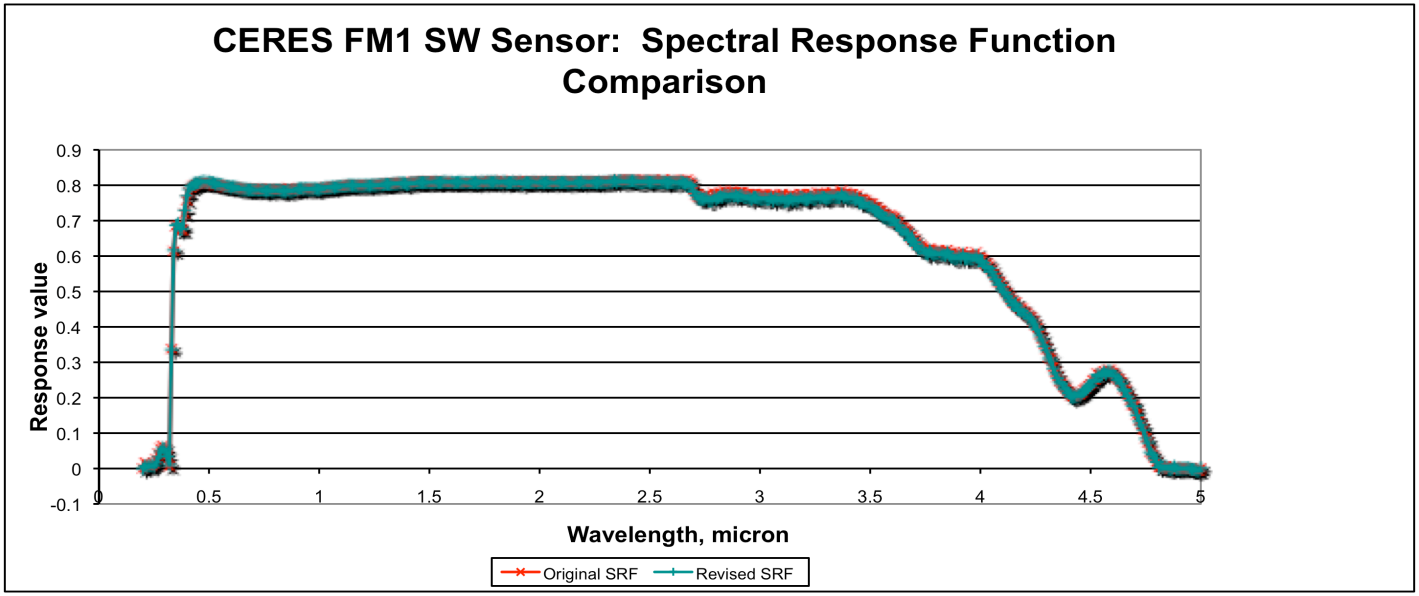
- Shortwave Reference Source (SWRS) uses 13 narrow-band filters in 0.4 to 2.0 micron region
- A Transfer Active Cavity radiometer (TACR) is used to place these narrow-band sources on same radiometric scale as the Narrow Field of View Blackbody (NFBB), the standard reference source.
- The relative spectral response at each SW spectral band is defined by ratioing the sensor and TACR measurements.
- Measurements of optical components are used to determine the spectral response for regions between these SW sources and to extend it below the 0.4 micron region.

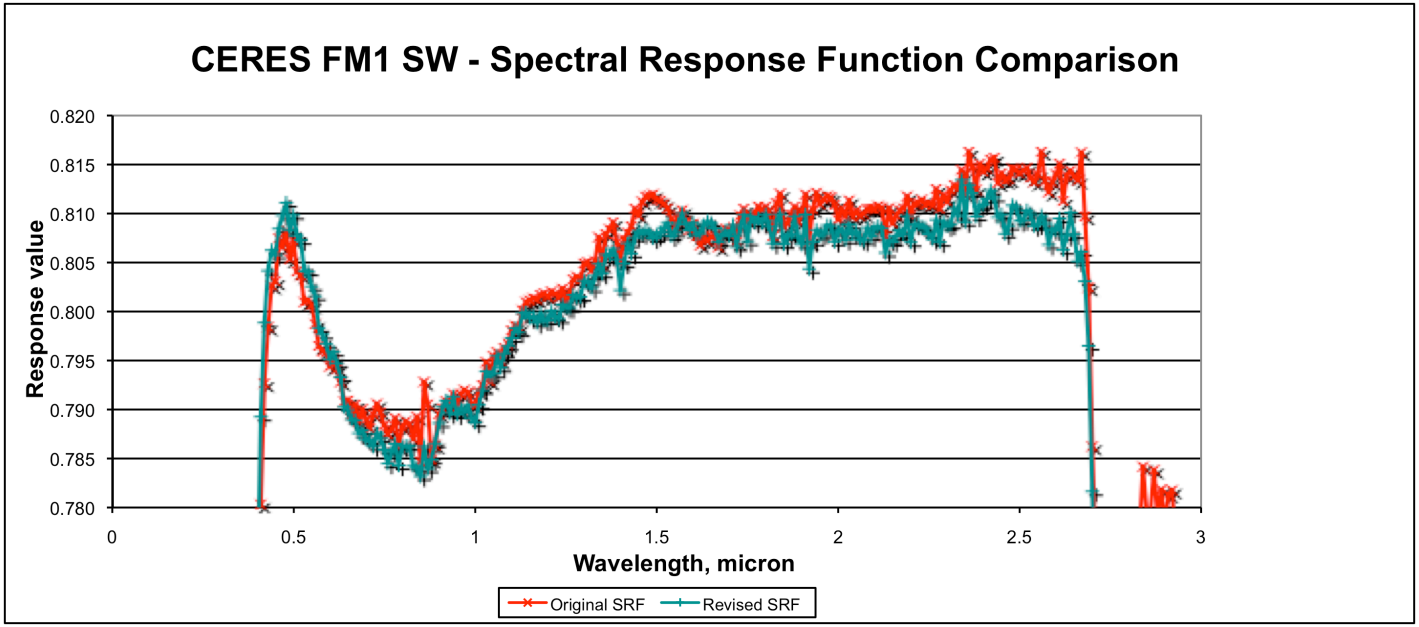
CERES SW Spectral Characterization

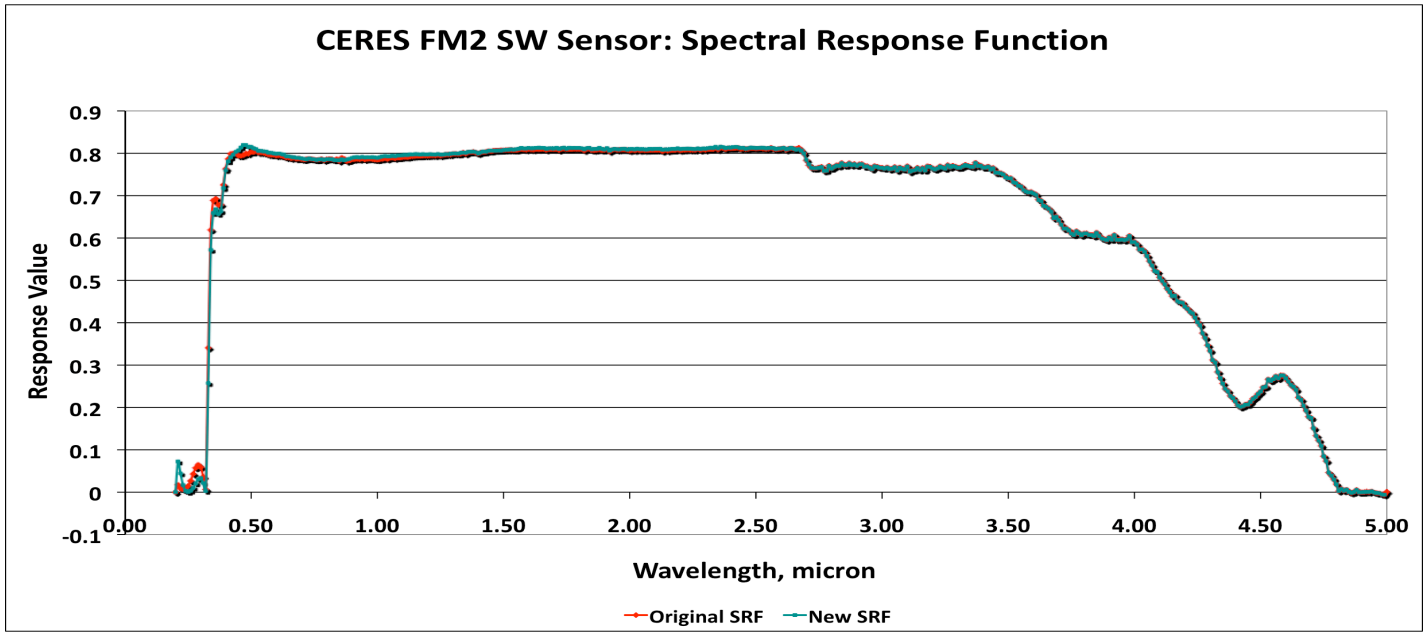
Re-evaluation of SW optical components:

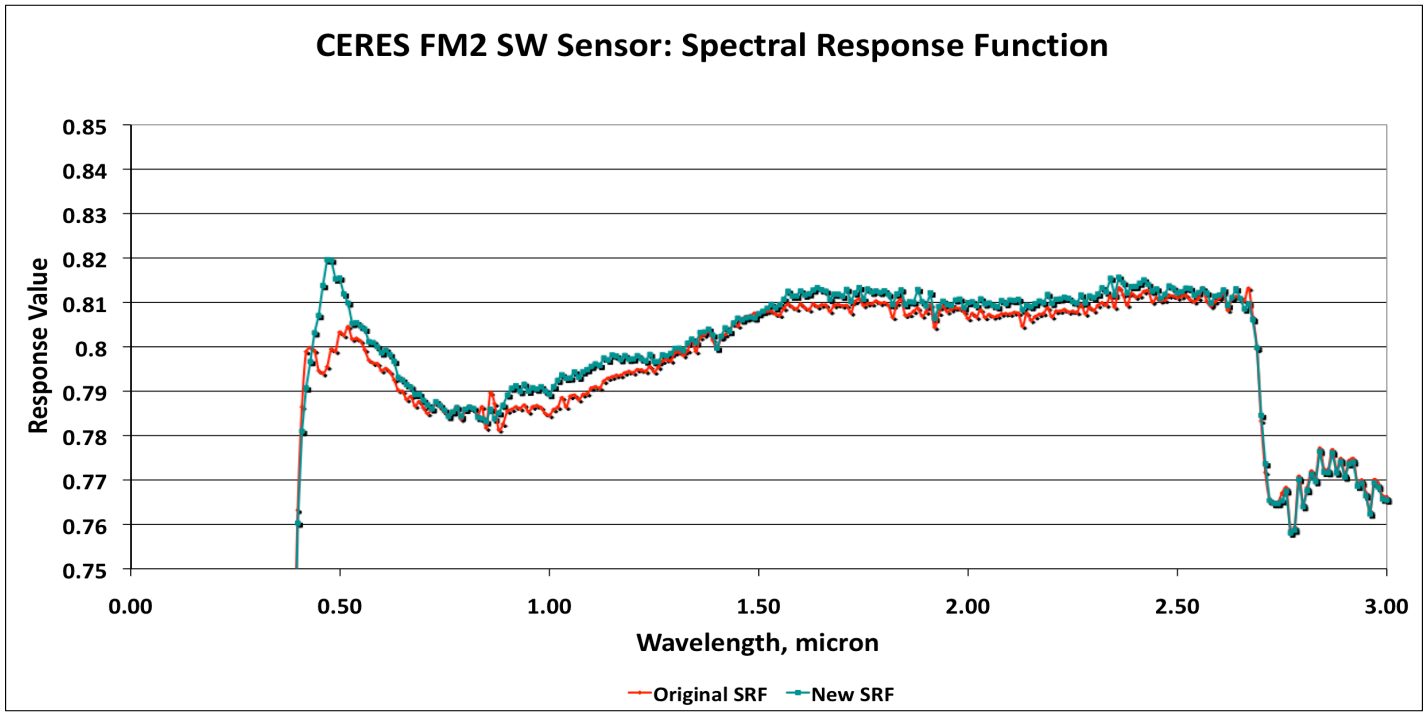
- Silver witness sample measurements from individual coating runs of the mirrors
- Consistency in tying silver measurements from different wavelength regions
- Band filter wavelengths were defined by combining SWRS lamp spectral output to the narrow band filter characteristics.

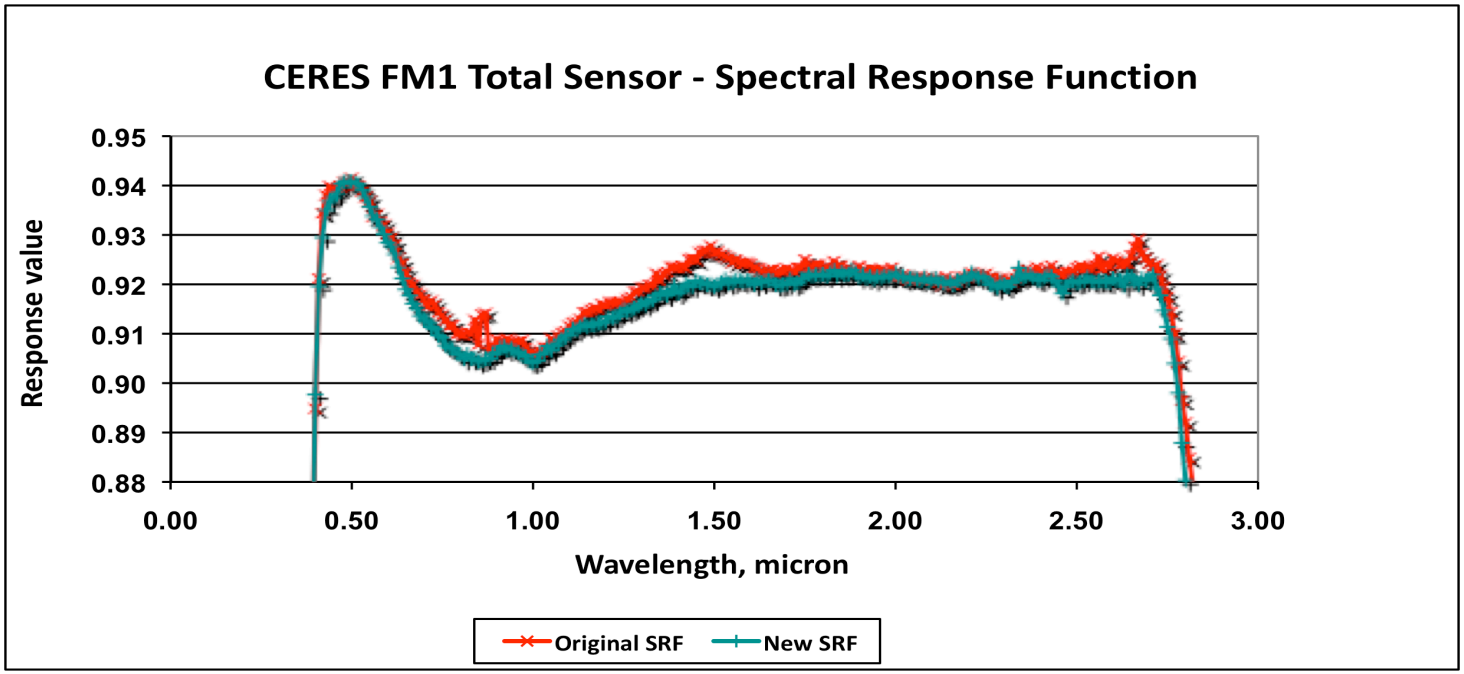

CERES FM1 and FM2 Sensors: Silver Measurements
Reflectance
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
300
800
1300
1800
2300
2800
Wavelength, nm
FM2
FM1
Original

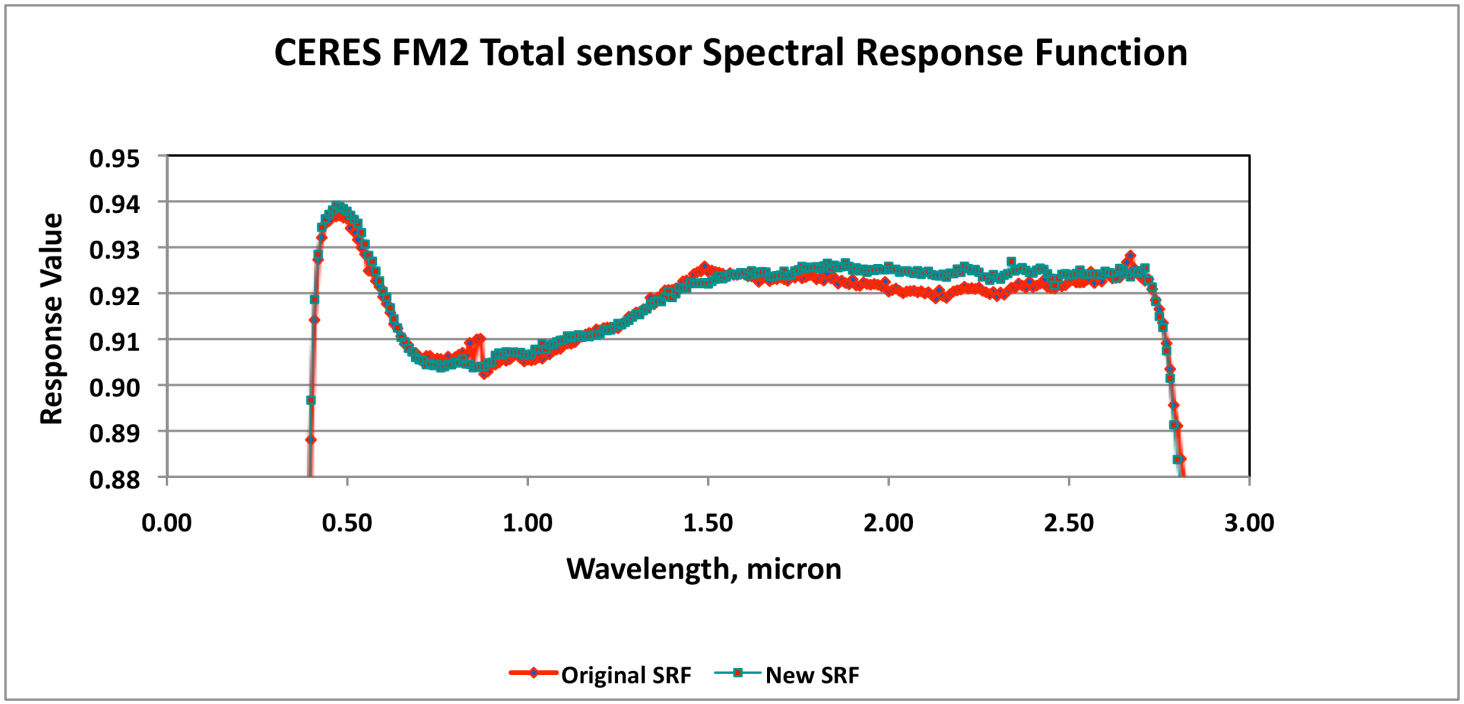

CERES FM1 SW Sensor: Spectral Response Function Comparison
Response value
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Wavelength, micron
Original SRF
Revised SRF


CERES FM1 SW - Spectral Response Function Comparison
Response value
0.820
0.815
0.810
0.805
0.800
0.795
0.790
0.785
0.780
0
0.5
1
1.5
2
2.5
3
Wavelength, micron
Original SRF
Revised SRF


CERES FM2 SW Sensor: Spectral Response Function
Response Value
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
Wavelength, micron
Original SRF
New SRF


CERES FM2 SW Sensor: Spectral Response Function
Response Value
0.85
0.84
0.83
0.82
0.81
0.8
0.79
0.78
0.77
0.76
0.75
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Wavelength, micron
Original SRF
New SRF


CERES FM1 Total Sensor - Spectral Response Function
Response value
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Wavelength, micron
Original SRF
New SRF


CERES FM2 Total sensor Spectral Response Function
Response Value
0.95
0.94
0.93
0.92
0.91
0.90
0.89
0.88
0.00
0.50
1.00
1.50
2.00
2.50
3.00
Wavelength, micron
Original SRF
New SRF

Radiance Comparison with Schiamachy Spectra

Scene	Unfiltered Radiance	Filtered Radiance Original SRF	Filtered Radiance New SRF	Percent Change in Radiance
Clear Ocean	21.4744	15.6414	15.6941	0.33
DCC	280.921	218.503	218.653	0.068
Clear Desert	93.7158	73.2769	73.2543	0.031
Clear Snow	101.465	78.9234	79.0018	0.099
Clear E-Forest	38.4567	29.3927	29.3987	0.02